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ABSTRACT

This study sought to determine whether the local perception of effort (RPE) for the leg performing predominantly positive work was significantly greater than for the leg performing predominantly negative work, during bench stepping. A second objective was to determine the effects of indomethacin (ID), an anti-inflammatory drug, on local RPE sense. Thirty-nine males were randomly assigned to a drug (ID) or a placebo (P) group. Local RPE was recorded separately for the right leg and left leg every 3 minutes during 30 minutes of bench stepping. For the P group, results indicated no significant differences between RPE for "concentric" and "eccentric" limbs although the metabolic demand of the "concentric" limb was presumably greater. When comparing the P and ID groups, indomethacin did not significantly alter RPE at any specific time during stepping; however, when RPE scores were totaled over the entire bench stepping period, the ID condition was associated with a greater perception of effort for the "concentric" leg as compared to the P condition. This suggested that indomethacin might alter effort sense related to concentric contractions. Eighteen references and three figures are provided. (JD)

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PERCEIVED EXERTION IN THE "CONCENTRIC" AND "ECCENTRIC" LEG DURING BENCH STEPPING AND THE EFFECT OF INDOMETHACIN ON THIS PERCEPTION

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The primary objective of this study was to determine whether the local perception of effort (RPE) for the leg performing predominantly positive work was significantly greater than for the leg performing predominantly negative work, during bench stepping. A second objective was to determine the effects of indomethacin (Id), an anti-inflammatory drug, on local RPE sense. Thirty-nine males were randomly assigned to a drug (Id) or placebo (P) group and administered 150 mg indomethacin or placebo, beginning 36 h prior to stepping. Local RPE was recorded separately for the right leg and left leg every 3 min during 30 min of bench stepping. For the P group, results indicated no significant differences ($p<.05$) between RPE for "concentric" and "eccentric" limbs although the metabolic demand of the "concentric" limb was presumably greater. When comparing the P and Id groups, Indomethacin did not significantly alter RPE at any specific time during stepping; however, when RPE scores were totaled over the entire bench stepping period, the Id condition was associated with a greater ($p < .01$) perception of effort for the "concentric" leg as compared to the P condition. This suggested that indomethacin might alter effort sense related to concentric contractions.

1. Introduction

Differences in perceived exertion (RPE) in response to positive and negative cycling (Henriksson et al., 1972) and ladder climbing (Pandolf et al., 1978) have been examined. At equal workloads a bout of eccentrically-biased exercise was always perceived as being significantly less stressful than a bout of concentrically-biased exercise. It is not known, however, how an individual would report local perceived exertion during a bout of exercise which combines both types of contractions in contralateral limbs, at equal resistance (body weight), and with an equivalent cardiorespiratory response as occurs during bench stepping. One objective of this study was to determine the differences in local RPE between the "concentric" and eccentric" leg during bench stepping.

A second objective of this study was to determine the effects of an anti-inflammatory drug, indomethacin (Id), on overall and local RPE. A limited amount of evidence (Fred, 1980; Fred, 1981; Hunter & Davis, 1982) suggests that aspirin-like drugs reduce sensations of pain in muscles and joints during exercise. Ekblom and Goldfarb (1971) have suggested that pain sensations might be one of the contributing factors to local perception of effort. It is now well established (Amadio, 1984) that the therapeutic effects of aspirin-like drugs are derived from the peripheral inhibition of prostaglandins, a local hormone.

Prostaglandins have numerous biologic functions (Amadio, 1984) including sensitizing local pain receptors (Ferreira, 1979) to chemical, mechanical and thermal stimuli. Increased prostaglandin activity (Dietze, 1981; Wennmalm, 1982; Day, 1981) has been observed during exercise; however, what stimulates their biosynthesis and what role they play during an exercise bout is still speculative.

2. Method

2.1 Subjects and Drug Condition

The VO2 max was measured prior to the bench stepping/resting condition using a standard Bruce protocol on a motor-driven treadmill (1972). To determine body fat, three sites were measured according to the Jackson and Pollock generalized equation (1978). Informed consent was obtained from all subjects; this was in accordance with the policy statement of the American College of Sports Medicine and the Institutional Human Subjects Committee.

A double-blind design was used to randomly assign 39 healthy, male volunteers (Table 1) to either drug (Id, N=19) or placebo (P, N=20) condition. The Id group received 100 mg of indomethacin (Indocin, 4x25 mg, provided by Merk, Sharp and Dohme) on the day prior to and then 50 mg (2x25 mg) on the morning of bench stepping. All step tests were conducted in the early afternoon. The P group was required

to take six placebo capsules at times equivalent to drug administration in the Id group.

Insert Table 1 about here

2.2 Bench Stepping

All subjects performed 30 min of continuous bench stepping at a rate of 15 step-ups min-1; each contraction lasted 1 s with the cadence determined by an electronic metronome. Throughout the step test the quadriceps of the leading limb contracted concentrically during the step-up, whereas the contralateral quadriceps contracted eccentrically by controlling the step down. The lead limb was determined by alternating left and right limb for each subject; i.e. if the right limb was the lead limb for subject one, then the left limb would lead for subject two. The bench height was adjusted for each subject to elicit approximately 55% of VO2max; however, if the heart rate exceeded 160 bt min-1 at 9 min, the bench was lowered by 7.5 cm to ensure that the subject would complete the 30 min of stepping.

2.3 Perceived Exertion and Heart Rate

RPE and heart rate were recorded at 3 min intervals. An electrocardiographic recorder (CM5 bipolar lead) was used to monitor heart rate. Borg's (1982) 10-point ratio scale was used to monitor rating of perceived exertion (RPE).

Prior to the step test, subjects were shown the scale and asked to carefully read the numbers and corresponding verbal descriptors. One of the technicians then read aloud a written set of instructions concerning RPE.

At each 3 min interval subjects first reported the overall RPE and then reported the local RPE for the left leg and the right leg; subjects alternated between reporting the left limb or the right limb first. Immediately before assigning a numeral to the limb in question, they were asked to touch that limb and were also encouraged to compare sensations in both limbs.

2.4 Statistical Analysis

A three-factor design (2x3x10) with repeated measures on the last two factors was used to test the hypotheses. The factors were drug groups (Id/P), feelings of effort (overall/"concentric"/"eccentric" limb) and time (10 measures); the dependent measure was RPE score.

3. Results

No significant differences were found between feelings of effort in the "concentric" and "eccentric" limb for the P subjects (Figure 7).

Insert Figure 1 about here

At no time during the test was there a significant difference between the combined RPE scores for Id vs P

(Figure 8). Combined RPE score represented the algebraic sum of overall, plus right limb, plus left limb RPE, recorded at each 3 min. interval.

Insert Figure 2 about here

However, when RPE scores for the overall, for the "concentric" limb and for the "eccentric" limb were summated across time and then compared by treatment group, the "concentric" limb of Id subjects was perceived as requiring greater effort ($p < .01$) than the "concentric" limb of P subjects (Figure 9).

Insert Figure 3 about here

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4. Discussion

Henriksson and co-workers (1972) and Pandolf and co-workers (1978) found that cycling on a modified bicycle ergometer or climbing a motor-driven ladder first in a predominantly concentric mode and then in a predominantly eccentric mode, but at equal absolute loads, the concentric exercise was perceived as requiring a significantly greater amount of overall effort. This finding is not surprising considering that the metabolic cost for positive work may be three to five times greater (Pandolf et al., 1978) than that

for an equivalent negative work load. During a bout of bench stepping, Newham and co-workers (1983) did not specifically measure local RPE, but reported that their subjects experienced minimal effort sense in the eccentric quadiceps, while the concentric contractions during the step-up required somewhat more effort.

Our results did not reflect these major differences seen between concentric and eccentric contractions. During bench stepping, although the limb used to control the descent of the body from the top of the bench was at all times perceived as requiring less effort than the limb used to raise the body, the differences in RPE between the two limbs were minimal. A possible explanation for our results differing from those of Newham and co-workers (1983) could be related to the intensity of the exercise. At the end of their 20 minute bout of bench stepping their subjects reported that the exercise bout did not feel very strenuous and had final heart rates which varied between 115 and 145 beats.min. Practically all of our subjects reported that the 30 minutes of bench stepping was very strenuous and had final heart rates of 158 $\pm$ 6 and 163 $\pm$ 4 (mean and standard error) for the Id and P, respectively. Therefore, if local cues do play an important role in effort sense as has been suggested (Henriksson et al, 1982), then some modification of this information must have occurred along the neural pathway in the bout of strenuos bench stepping.

No significant differences were seen between RPE of Id and P at any one time during the 30 min of exercise, but when cumulative effects for the entire exercise bout were examined, the "concentric" leg of the drug group was perceived as requiring significantly more effort ($p<.01$) than the "concentric" leg of the placebo group. Although a double-blind method was used to randomly assign subjects to the drug or placebo group, a T-test revealed a significant difference between groups in VO2 max ($p<.05$) (Table 1). Furthermore, the differences in body weight between groups almost reached significance ($t=2.02$, critical value $=2.03$) The fact that the drug group was heavier and had a significantly lower VO2 max could be one explanation for their greater local effort sense in the leg performing the stepping up. An alternate explanation could be that indomethacin inhibits prostaglandin synthesis (Amadio, 1984). Although somewhat controversial (Wennmalm, 1982), prostaglandins of the E series appear to be involved in exercise hypermia. The metabolic cost (and consequently oxygen demands) for concentric contractions (Davies & Barnes, 1972) is much greater than for eccentric contractions at equal workloads. As prostaglandins have a vasodilatory effect (Wennmalm, 1982), inhibition of their biosynthesis might result in a reduced perfusion of this area. The result might induce a greater dependence on anaerobic metabolism, leading to a greater accumulation of

lactate in local tissues. As muscle lactate correlates closely with the 10-point Borg scale (Noble, Borg, Jacobs & Ceci, 1983), this could account for the greater feelings of effort in the "concentric" limb experienced by the drug subjects.

The appropriateness of the Borg category-ratio scale for monitoring RPE during eccentrically-biased exercise should be carefully examined. Although Noble and coworkers (1983) found a strong correlation between these ratings and blood muscle lactate during a progressive maximal exercise test on a cycle ergometer, lactate production during eccentrically biased exercise is minimal (Bonde-Peterson & coworkers, 1972). Furthermore, although the RPEs reported for each limb throughout the bench stepping test in the present study were similar, the underlying sensations described by subjects in this study and those reported in other similar studies (Davies and White, 1981) appeared to differ considerably; adjectives such as "tired" and "achy" were used for the concentric limb and "weak," "shaky," and "rubbery" were used for the eccentric limb. Such qualitative differences cannot be reflected within the framework of the Borg scale.

5. Conclusions

Minimal differences in effort sense were perceived between the limb performing predominantly eccentric contractions and the contralateral limb performing

predominantly concentric contractions during bench stepping for all subjects receiving a placebo. It was suggested that this lack of differentiation resulted from neural modification at some level of the spinal cord. Concerning the second objective of the study, administration of a prostaglandin inhibitor appeared to alter local RPE related to concentric contractions but not to eccentric contractions. It was speculated that this increase in effort sense in the concentrically contracting quadriceps was a result of a reduced vasodilatory response in this limb due to the drug administration.

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Table 1. Physical Characteristics of Subjects in the Drug and Placebo Group

	Indomethacin Group, N=19	Placebo Group, N=20
Age (yrs)	25.0 ± 1.4	23.4 ± 1.3
Weight (kg)	78.8 ± 4.5	71.8 ± 2.7
Body fat (%)	13.6 ± 1.8	11.1 ± 1.6
VO2 max (ml/kg/min)	39.0 ± 1.9	43.0 ± 1.*

Values are means ± standard error.

* =p<.05 between indomethacin and placebo group.

FIGURE LEGENDS

FIGURE 1. Local RPE in the "Concentric" and "Eccentric" Limb of placebo subjects during bench stepping. Values represent means and standard error of means.

FIGURE 2. Combined RPE scores for Indomethacin vs Placebo subjects. The combined score represents the mean of the sum of RPE for the overall, the left and the right limb. Values represent means and standard error of means.

FIGURE 3. Total RPE scores for Indomethacin and Placebo subjects for 30 minutes of bench stepping. Values represent means and standard error of means (**p<.01 compared to placebo group).

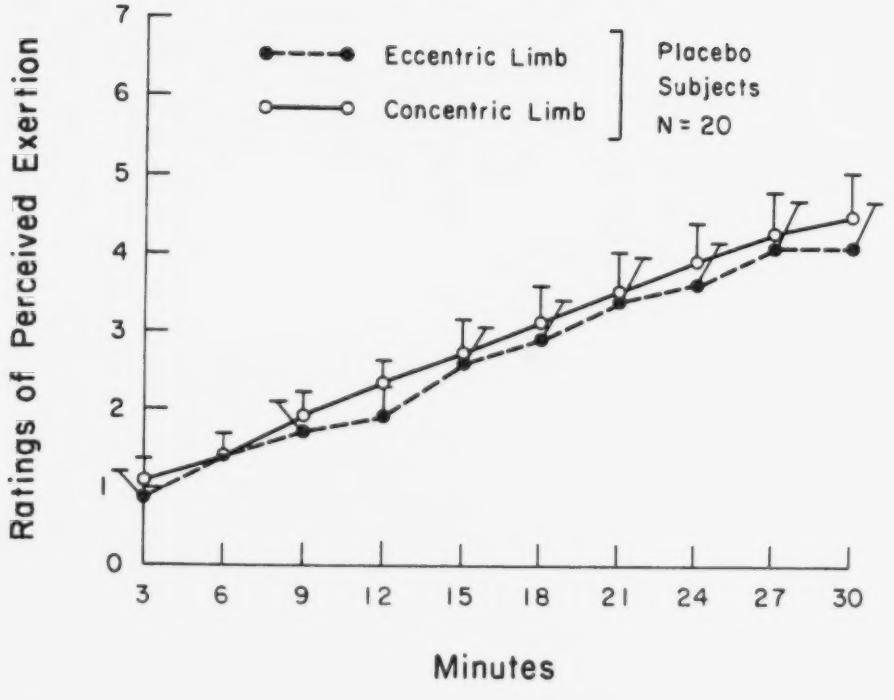
Ratings of Perceived Exertion
7
6
5
4
3
2
1
0
Eccentric Limb
Concentric Limb
Placebo
Subjects
N = 20
3
6
9
12
15
18
21
24
27
30
Minutes

FIGURE I

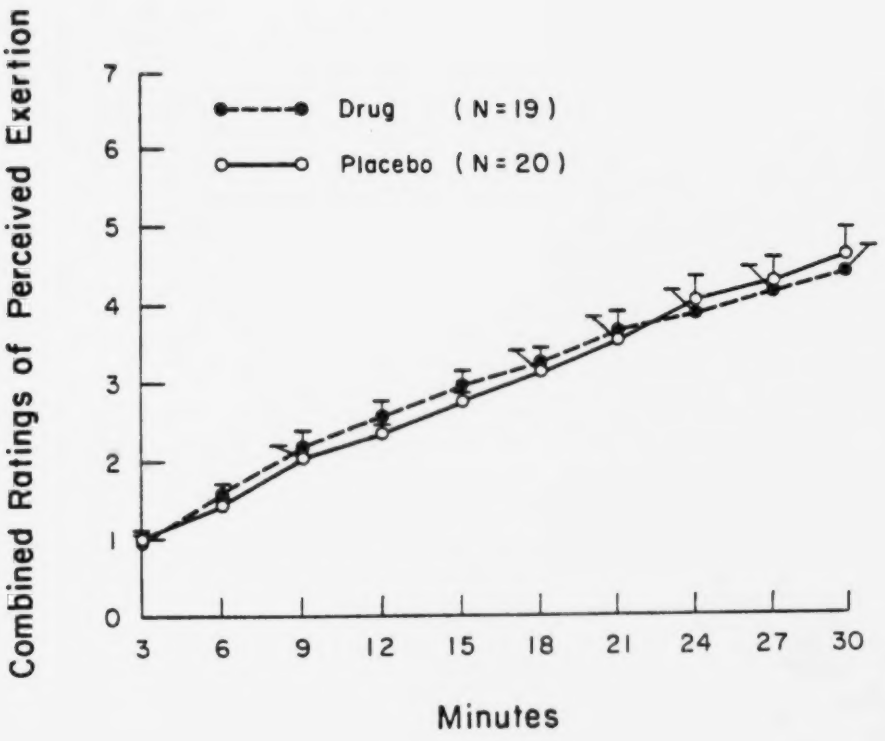
Combined Ratings of Perceived Exertion
Drug (N=19)
Placebo (N=20)
0
1
2
3
4
5
6
7
3
6
9
12
15
18
21
24
27
30
Minutes

FIGURE 2

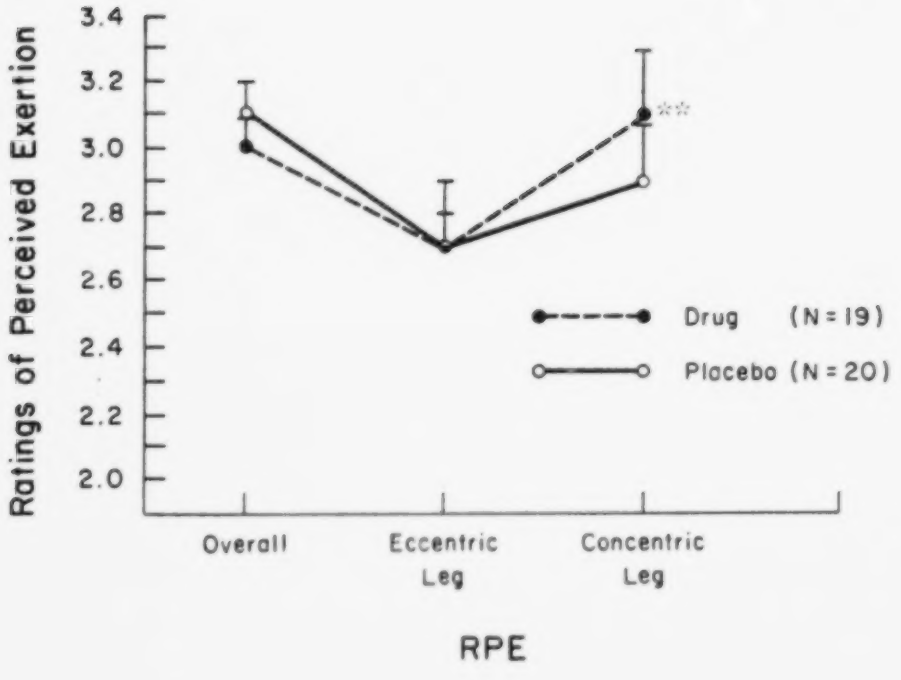
Ratings of Perceived Exertion
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
**
Drug (N = 19)
Placebo (N = 20)
Overall
Eccentric Leg
Concentric Leg
RPE

FIGURE 3